

Kansas Department of Health and Environment
Report of Radiological Environmental Monitoring of the Environs Surrounding
Wolf Creek Generating Station



July 2009-June 2010
Division of Health, Bureau of Environmental Health
Radiation and Asbestos Control Section
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Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
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INTRODUCTION

Wolf Creek Generating Station (WCGS) is a pressurized water nuclear reactor capable of producing over 1,200 megawatts of electrical power. Located near Burlington Kansas, the plant is operated by Wolf Creek Nuclear Operating Corporation (WCNOC). The facility releases radioactive material to the environment in the form of liquid and gaseous effluents. This report details the results of surveillance of the environs surrounding WCGS conducted by the Kansas Department of Health and Environment (KDHE) from July 1, 2009 through June 30, 2010.

KDHE's Wolf Creek Environmental Radiation Surveillance (ERS) program began in 1979 in accordance with Kansas Administrative Regulation (K.A.R.) 28-19-81 with the initial selection of surface water sampling locations. The ERS program was ready for operational use in 1984, which allowed for one year of baseline data collection prior to the commercial operation of WCGS, which commenced in September 1985. The ERS program parallels (and partially overlaps) the WCNOC Radiological Environmental Monitoring Program (REMP).

The purpose of the ERS program is to detect, identify, and measure radioactive material released to the environment from the operation of WCGS. Data indicating the release of elevated levels of radioactive material will be used to determine the need for corrective and/or protective actions to protect the health and safety of the public.

The ERS program includes the following monitoring methods:

- Measurement of ambient external radiation levels using optically stimulated luminescence dosimetry
- Monitoring of radionuclides present in ambient air through weekly collection and laboratory analysis of continuous air samples
- Monitoring of radionuclides present in water, terrestrial vegetation, aquatic vegetation, fish, sediments, and soil through scheduled and random sample collection and laboratory analysis.

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RESULTS SUMMARY

The most significant radionuclide present in surface water samples collected in the Coffey County Lake is tritium (^3H), a beta emitter. The highest ^3H concentration measured in the Coffey County Lake during SFY 2010 was 13,706 pCi/l in December, 2009. This maximum Coffey County Lake ^3H concentration is 69% of the National Primary Drinking Regulation maximum contaminant level (MCL) of 20,000 pCi/l. *The water from the Coffey County Lake is not used as a drinking water source.* The average CCL surface water ^3H concentration for SFY 2010 was 12,665 pCi/l, or 63% of MCL. Coffey County Lake is not approved for any aquatic recreation other than fishing. All other non-CCL surface water and ground water samples collected in the environs of WCGS during SFY 2010 indicated no radionuclides present attributable to the operation of WCGS.

Aquatic vegetation samples are the best indicators for monitoring the seasonal fluctuations of fission and activation product levels in the Coffey County Lake. No aquatic vegetation sample showed any nuclides attributable to WCGS operation. Five trending samples and six random samples were analyzed.

Sediment samples have been excellent indicators for the long-term buildup of fission and activation product activity levels in the Coffey County Lake. The highest fission product activity in sediments during SFY 2010 was 203.5 pCi/kg-dry ^{137}Cs found in Coffey County Lake random sample.

Airborne sample analysis indicated that no radionuclides attributable to the operation of WCGS were present above the lower limits of detection during SFY 2010.

Sample analysis of terrestrial vegetation, soil, milk, grain, and vegetable samples collected in the environs of WCGS during SFY 2010 indicated no radionuclides present attributable to the operation of WCGS.

Samples of eight species of fish were taken from the Coffey County Lake during SFY 2010. Sample analysis of edible fish portions collected in the environs of WCGS during SFY 2010 indicated that no gamma emitters attributable to WCGS operation were present. The highest ^3H concentration in tissue was 7,662 pCi/kg-wet found in a smallmouth buffalo sample taken from the CCL. Using an ICRP 30 dose conversion factor for ingestion ($h_{E,50}$) of 6.40×10^{-8} mrem per pCi ^3H ingested, a standard man consuming 21 kg/y of fish containing 7,662 pCi/kg ^3H would receive a committed effective dose equivalent of 0.1 mrem. The projected dose equivalent is far below the 100 mrem/yr regulatory limit for a member of the public.

Data from direct radiation monitoring sites revealed no significant changes from preoperational data. The lowest direct radiation levels are found closest to the WCGS. The direct radiation levels on the Coffey County Lake baffle dikes at the 1,200 m exclusion

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area boundary are the lowest of any monitored site. The limestone used to construct the baffle dikes has a lower natural background radioactivity than the original soil present before the construction of the Coffey County Lake. This effect of construction on the terrestrial component of natural background radiation was noted on radiation surveys conducted around the WCGS site before bringing the initial fuel load on the site. The water from the Coffey County Lake also acts as an effective shield from terrestrial radiation that was present before Coffey County Lake filling.

The ratio of KDHE results to WCNOG results ranged from 0.9-1.6. A summary of comparison data may be found in the Results Comparison Table.

Results Summary Table

Type of Sample	Number of Sampling Stations	Total Samples Collected
Air (particulate and iodine)	5	520
Soil	5	5
Random Soil	10	10
Direct Radiation	31	248
Surface Water	5	47
Offsite Ground Water	6	24
Onsite Ground Water	3	12
Sediments	9	9
Random Sediments	16	17
Aquatic Vegetation	5	5
Random Aquatic Vegetation	6	6
Milk	2	8
Fish	2	21
Game Animals/Domestic Meat	1	1
Terrestrial Vegetation	7	9
Random Terrestrial Vegetation	10	10
Total	123	952

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Results Comparison Table

Description	Average	Standard deviation	Min	Max	N
OSLD direct radiation, mR per 90 day quarter	17.6	2.25	9.1	23.0	124
Airborne particulate and radioiodine cartridge gamma isotopic analysis	Gamma isotopic analysis indicated that no gamma emitters attributable to Wolf Creek Generating Station operation were present above the lower limits of detection in any air particulate filter or radioiodine cartridge evaluated.				
Surface water tritium (³ H), pCi/l					
John Redmond Reservoir, control (N-1/MUSH)	<350	--	--	--	12
Coffey County Lake (J1A)	12735.8	1098.1	10439	13706	12
Coffey County Lake (MUDS)	12594.5	941.6	10635	13649	12
Neosho River Near Leroy	<350	--	--	--	10
Ponds surrounding WCGS	<350	--	--	--	1
Offsite ground water tritium (³ H), pCi/l (All Stations)	<350	--	--	--	24
Onsite ground water tritium (³ H), pCi/l (Stations where activity was detected)	1269	524	487	2106	8
Water sample gamma isotopic analysis	Gamma isotopic analysis indicated that no gamma emitters attributable to Wolf Creek Generating Station operation were present above the lower limits of detection in any surface water, drinking water, or ground water sample evaluated.				
Gamma isotopic analysis of soil, pasturage, garden vegetables, and grain.	Gamma isotopic analysis indicated that no gamma emitters attributable to Wolf Creek Generating Station operation were present above the lower limits of detection in any soil, milk, pasturage, garden vegetable and grain sample evaluated.				
Maximum activity attributable to Wolf Creek Generating Station operation, pCi/kg					
Coffey County Lake bottom sediment, dry	¹³⁷ Cs 203.5 ± 1.8 Coffey County Lake				
Coffey County Lake fish, wet	³ H 7662 ± 301 Coffey County Lake				
Analysis	Average Ratio of KDHE results to WCNOG results		Comments		
OSLD Direct Radiation	1.6 N=48		12 collocated sites.		
Surface Water ³ H	1.1 N=12		Coffey County lake spillway		
Sediment gamma isotopic	1.2 N=2		Comparison of ¹³⁷ Cs results		
Fish tritium (³ H) in tissue	0.9 N=3		Comparison of ³ H results.		

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SAMPLE RESULTS

Attachment 1: Inhalation Pathway

Air Samples

Air samples were collected weekly. Five air-sampling sites, four of which are collocated with WCNOG, have continuously operating low-volume air samplers contained in a fiberglass housing mounted on utility poles approximately one meter from the ground. Air samplers are located at Sharpe, KS (A-1), east of the Coffey County Lake dam (H-1), Burlington, KS (L-1), New Strawn, KS (P-1), and near Westphalia, KS (D-2). The collocated sites include the highest calculated annual average ground level relative concentration (X/Q) area at Sharpe, the highest calculated annual average ground level relative deposition (D/Q) area at New Strawn, and a control location near Westphalia. An average flow rate of 30 liters per minute is used with 47 mm diameter glass fiber particulate filters and 5 percent triethylenediamine (TEDA) impregnated carbon cartridges for radioiodine activity (the major isotope of concern is ^{131}I). TEDA binds the iodine chemically and reduces losses from desorption.

Field assay of each particulate filter was performed at the time of collection. The particulate filter was counted using a thin window GM 'pancake' detector (Ludlum Model 44-40 or equivalent) and a count rate instrument. A sample net count rate of greater than two times the net count rate of the current control (Westphalia D-2) air sample indicates a potential anomaly and the filter is then flagged for individual gamma isotopic analysis.

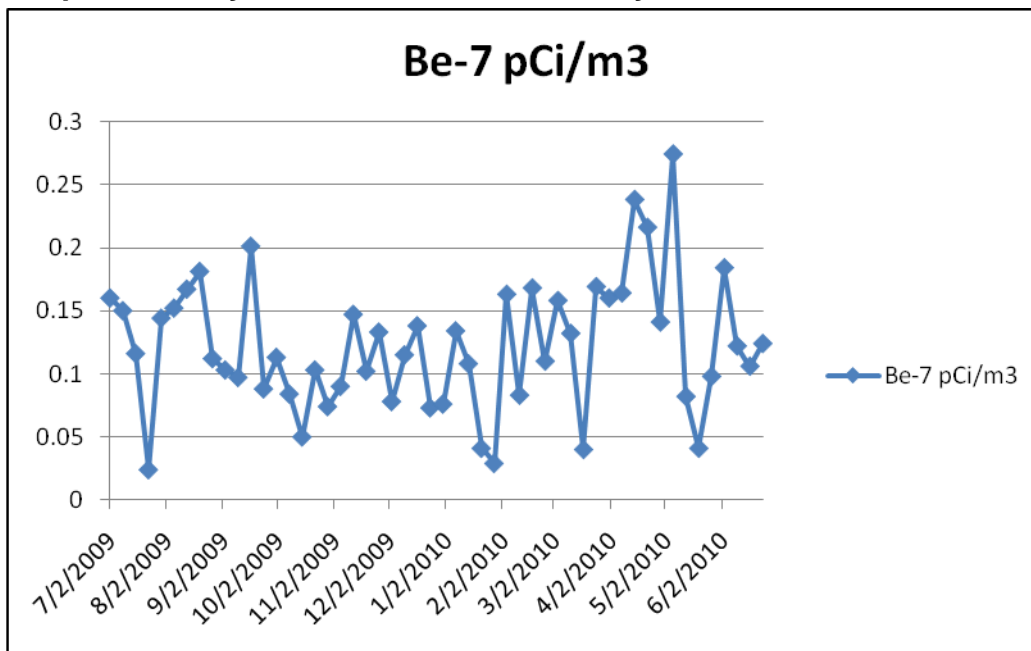
Gamma isotopic analysis was performed on two composite samples, one composed of the five particulate filters and the other of the five charcoal cartridges. Indication of ^{131}I or any other fission or activation product requires gamma isotopic analysis of each individual particulate filter and associated charcoal cartridge.

Table 1: Weekly Air particulate/iodine monitoring

Number of Samples	Average ^7Be Concentration	Average Iodine Concentration
52	0.12 ± 0.007	<0.03

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Graph 1 Weekly Air Particulate ⁷Be Activity



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Attachment 2: Airborne Pathway

Soil Samples

Four indicator, one control, and ten random annual soil samples were collected. Indicator soil samples were collected near Stringtown Cemetery, east of the CCL dam, at the CCL MUDS area, and at the public environmental education area. One control soil sample was collected east of WCGS at the Scott Valley Church. Random soil samples were collected at ten locations within the 50 mile zone around WCGS, nine of which were within the ten mile zone around WCGS. Soil samples collected from the Coffey County public use areas are split with WCNOG.

A gamma isotopic analysis is performed on all soil samples collected.

Table 2 Annual Samples for airborne radionuclide deposition on soil (pCi/kg dry)

Isotope	A-1 Near Stringtown Cemetery	E-1 Scott Valley Church (Control)	H-1 East of CCL Dam Near HCA H-1
	4/7/2010 0.5m ²	5/26/2010 0.5m ²	4/7/2010 0.5m ²
²²⁸ Ac	1448.7 ± 14.8	1623.2 ± 47.5	1032.1 ± 11.8
¹³⁷ Cs	322.3 ± 7.6	296.4 ± 20.6	311.7 ± 7.3
⁴⁰ K	12720.2 ± 281	16466.8 ± 848.2	13122.1 ± 311.7
	P-1 (MUDS) 6/2/2010	R-1 (EEA) 8/14/2009	
²²⁸ Ac	950.1 ± 13.8	1219.7 ± 21.4	
¹³⁷ Cs	143.6 ± 69.1 (<60.8)	23.6 ± 4.0 (285.2 ± 45.9)	
⁴⁰ K	10453.3 ± 143.6 (8791.4 ± 1143.0)	14765.4 ± 640.8 (13405.0 ± 771.0))	

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Table 3 Random samples for airborne radionuclide deposition on soil (pCi/kg dry)

Location	Date	Isotope	
		¹³⁷ Cs	⁴⁰ K
20th and Oxen	9/29/2009	<8.0	12198.1 ± 677.1
Near 10th and Underwood	10/27/2009	12.5 ± 1.8	9744.4 ± 245.3
20th and Fauna	11/3/2009	127.4 ± 3.6	14359.7 ± 326.1
11th and Native	1/27/2010	22.6 ± 2.5	16820.2 ± 375
Near 14th and Native	3/29/2010	<8.0	11589.6 ± 336.2
16th and Kafir RD	4/13/2010	44.7 ± 2.9	15381.6 ± 203.2
19th and Shetland	4/13/2010	157.8 ± 5.1	8464 ± 203.6
9th and Quail	5/11/2010	260.4 ± 7.2	11819.7 ± 159.2
Between Reaper & Shetland on 17th Rd.	5/26/2010	<8.0	13129.8 ± 172.3
18th Rd. Between HWY 75 and Native Rd.	6/9/2010	100.7 ± 4	12714.8 ± 173.9

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Attachment 3: Direct Radiation Pathway

OSLD Samples

Direct radiation monitoring was accomplished using Landauer Luxel optically stimulated luminescence dosimeters (OSLDs). OSLDs are read by Landauer. OSLD readings are corrected for transit and handling exposure.

Thirty-one locations around the WCGS were monitored by KDHE, including three control locations greater than ten miles from WCGS. Two OSLDs were used per site to generate an average quarterly reading. The dosimeters are contained in specially constructed holders suspended approximately one meter above the ground. Staff members exchange OSLDs quarterly. KDHE has collocated OSLDs with WCNOG at twelve sites.

Table 4: Quarterly direct radiation monitoring (mR)

Location	1 st Quarter	2 nd Quarter	3 rd Quarter	4 th Quarter
1. A-1 (1), North of WCGS	22.0	18.3	19.4	18.1
2. A-2, Sharpe	23.0	18.3	20.9	16.1
3. A-3, Forward Staging Area	18.5	16.8	17.4	14.1
4. B-1, East Sharpe	22.5	18.8	20.4	16.6
5. B-2, Waverly Control	21.0	17.8	17.9	16.6
6. C-1, near residence	18.5	17.3	18.9	16.1
7. D-1 (9), near residence	17.5	18.3	18.9	17.1
8. E-1, near residence	21.0	17.3	18.9	15.6
9. F-1, near residence	21.5	16.8	19.9	16.6
10. G-1 (14), WCNOG gate	20.0	18.3	17.4	17.1
11. H-0 (42), CCL baffle dike A	14.5	12.8	12.9	13.1
12. H-1, east of CCL dam	19.0	18.3	18.9	15.6
13. H-2, LeRoy control	20.5	17.8	17.9	15.6
14. J-1, near residence	16.5	18.8	19.4	16.1
15. K-1 (29), near residence	15.5	15.3	15.4	13.6
16. L-1 (27), near residence	20.5	18.3	18.9	16.6
17. L-2, Burlington	20.5	17.8	19.4	16.1
18. L-3, Coffey County Shop	18.5	18.3	18.4	15.6
19. M-1 (26), near residence	20.0	16.8	17.9	14.6
20. N-1, near pasture	18.0	17.8	19.4	16.1
21. P-0 (43), CCL baffle dike B	14.0	11.3	12.4	9.1
22. P-1, New Strawn	19.5	18.8	19.9	16.6
23. P-2, Hartford Control	16.0	17.3	18.9	13.6
24. P-3, CCL entrance	19.0	18.3	19.4	17.1
25. P-4 (46), CCL near MUDS	19.5	18.3	19.4	16.1
26. P-5, JRR public use area	18.0	17.8	19.9	17.1
27. Q-1, near residence	18.5	17.3	18.4	15.1
28. R-0 (41), Stringtown cemetery	20.0	15.8	15.9	17.1
29. R-1 (37), near residence	21.0	16.8	17.9	15.1
30. R-2 (44), CCL EEA	19.0	16.8	17.9	15.1
31. R-3, near Coffey County Airport	17.5	17.8	18.9	16.6

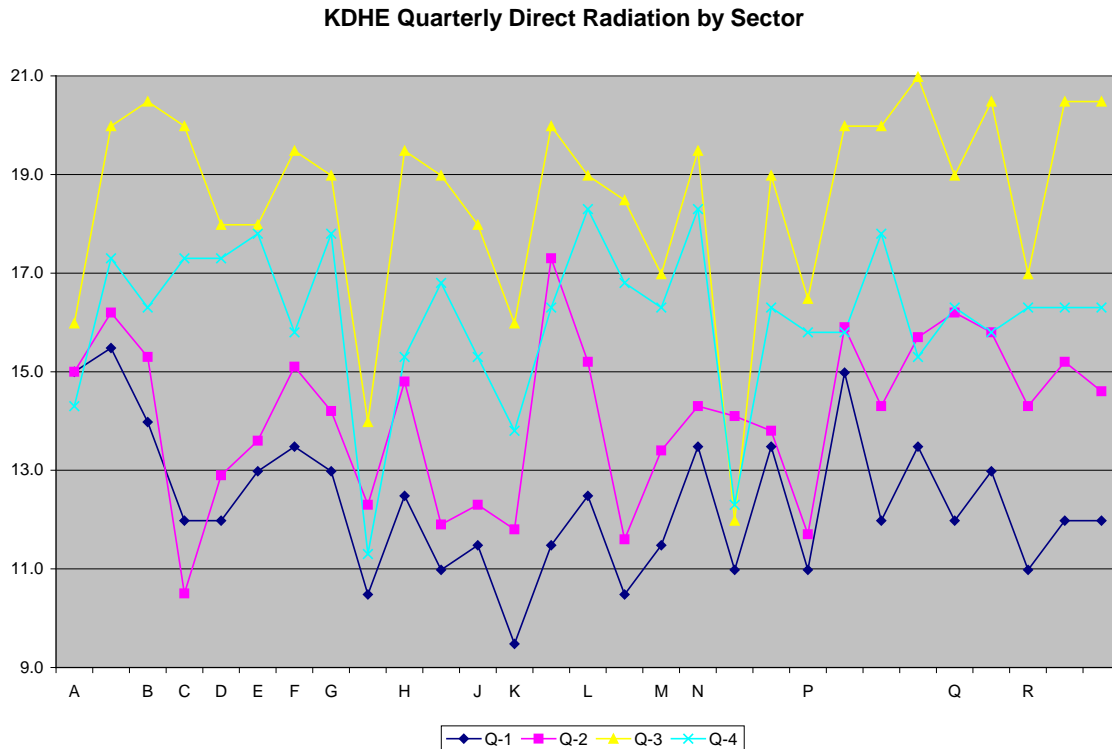
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Table 5 Co-located quarterly direct radiation monitoring (mR)

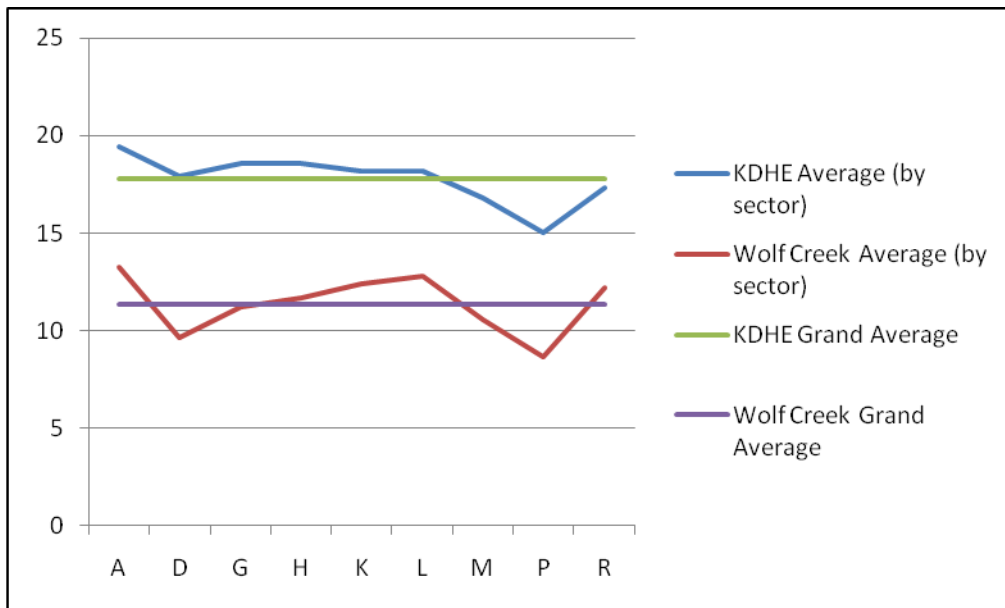
Location KDHE (WCNOC)	KDHE Monitoring period	KDHE	WCNOC
1. A-1 (1)	7/8/2009-10/13/2009	22.0	14.7
	10/13/2009-1/8/2010	18.3	13.4
	1/8/2010-4/7/2010	19.4	11.8
	4/7/2010-7/8-2010	18.1	13.2
2. D-1 (9)	7/8/2009-10/13/2009	17.5	9.4
	10/13/2009-1/8/2010	18.3	9.4
	1/8/2010-4/7/2010	18.9	10.1
	4/7/2010-7/8-2010	17.1	9.7
3. G-1 (14)	7/8/2009-10/13/2009	20.0	15.7
	10/13/2009-1/8/2010	18.3	11.2
	1/8/2010-4/7/2010	17.4	12.9
	4/7/2010-7/8-2010	17.1	11.4
4. H-0 (42)	7/8/2009-10/13/2009	14.5	6.8
	10/13/2009-1/8/2010	12.8	4.9
	1/8/2010-4/7/2010	12.9	6.0
	4/7/2010-7/8-2010	13.1	3.8
5. K-1 (29)	7/8/2009-10/9/2009	15.5	6.8
	10/9/2009-1/6/2010	15.3	8.0
	1/6/2010-4/6/2010	15.4	8.2
	4/6/2010-7/9-2010	13.6	9.2
6. L-1 (27)	7/8/2009-10/13/2009	20.5	13.6
	10/13/2009-1/8/2010	18.3	11.4
	1/8/2010-4/7/2010	18.9	9.9
	4/7/2010-7/8-2010	16.6	13.2
7. M-1 (26)	7/8/2009-10/13/2009	20.0	8.9
	10/13/2009-1/8/2010	16.8	8.8
	1/8/2010-4/7/2010	17.9	10.4
	4/7/2010-7/8-2010	14.6	10.1
8. P-0 (43)	7/8/2009-10/9/2009	14.0	6.3
	10/9/2009-1/6/2010	11.3	4.9
	1/6/2010-4/6/2010	12.4	4.4
	4/6/2010-7/9-2010	9.1	4.7
9. P-4 (46)	7/8/2009-10/13/2009	19.5	13.1
	10/13/2009-1/8/2010	18.3	11.0
	1/8/2010-4/7/2010	19.4	12.1
	4/7/2010-7/8-2010	16.1	12.3
10. R-0 (41)	7/8/2009-10/13/2009	20.0	13.6
	10/13/2009-1/8/2010	15.8	10.3
	1/8/2010-4/7/2010	15.9	10.7
	4/7/2010-7/8-2010	17.1	11.4
11. R-1 (37)	7/8/2009-10/13/2009	21.0	14.1
	10/13/2009-1/8/2010	16.8	12.5
	1/8/2010-4/7/2010	17.9	10.2
	4/7/2010-7/8-2010	15.1	13.2
12. R-2 (44)	7/8/2009-10/13/2009	19.0	14.1
	10/13/2009-1/8/2010	16.8	11.2
	1/8/2010-4/7/2010	17.9	10.7
	4/7/2010-7/8-2010	15.1	14.5

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Graph 2 Quarterly direct radiation results for KDHE OSLD sites (mR)

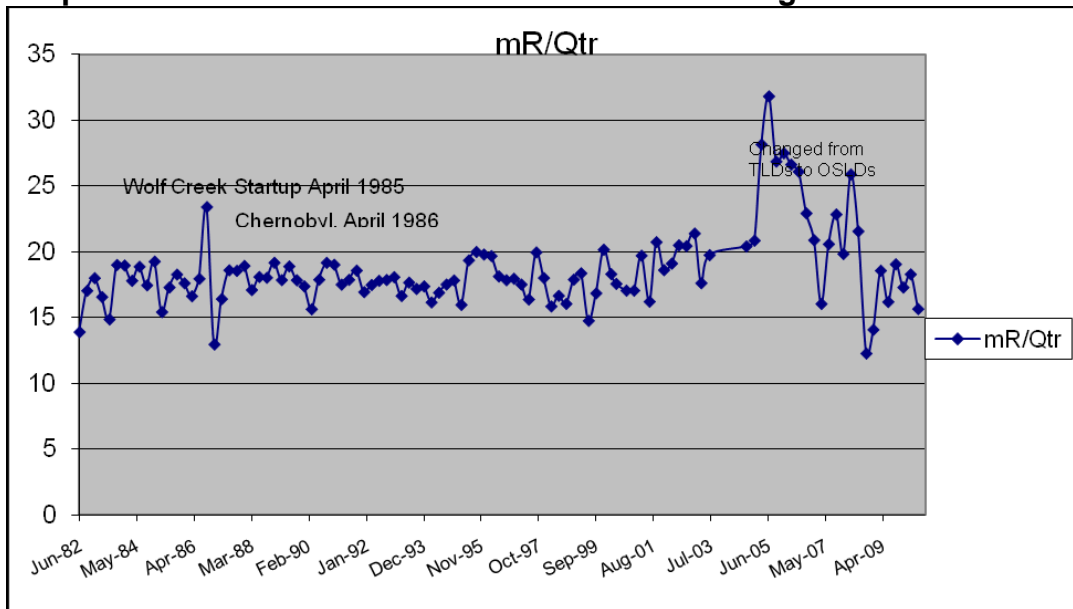


Graph 3 Direct radiation monitoring results for co-located OSLD sites (mR)



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Graph 4 Historical KDHE direct radiation monitoring results



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Attachment 4: Waterborne Pathway

Surface Water

Surface water sampling was accomplished through the collection of one-gallon grab samples at the indicated locations. A control sample was collected monthly from John Redmond Reservoir. One sample was collected monthly from the Coffey County Lake (CCL) at the spillway. One sample was collected monthly at the public fishing area on CCL, near the Makeup Discharge Structure (MUDS). Samples were collected monthly from the Neosho River near Leroy only when Coffey County Lake was overflowing to Wolf Creek at the spillway. No discharges to the river occurred during the July/August 2009 period. A sample was also collected annually from the New Strawn City Lake.

A gamma isotopic and tritium (^3H) analysis was done on each CCL water sample and ^3H analysis was done quarterly on a composite sample from JRR. Samples from John Redmond Reservoir and the Coffey County Lake Spillway were split with WCNOG.

Table 6 Monthly samples for waterborne radionuclides in surface water (pCi/L)

J-1A (Spillway)			N-1 (JRR/MUSH) Control		
Date	KDHE	WCNOG	Date	KDHE	WCNOG
7/9/2009	12722 ± 342	11615 ± 317	7/9/2009	<350	<147
8/10/2009	11784 ± 335	11252 ± 310	8/10/2009	<350	<142
9/21/2009	13683 ± 352	12830 ± 332	9/21/2009	<350	<152
10/13/2009	13674 ± 353	13351 ± 346	10/13/2009	<350	<152
11/10/2009	13265 ± 352	12635 ± 332	11/10/2009	<350	<150
12/21/2009	13706 ± 374	12386 ± 336	12/21/2009	<350	<150
1/27/2010	13344 ± 367	12165 ± 315	1/27/2010	<350	<163
2/22/2010	12436 ± 342	11841 ± 322	2/22/2010	<350	<152
3/29/2010	13674 ± 359	12324 ± 315	3/29/2010	<350	<177
4/22/2010	13001 ± 358	12195 ± 309	4/22/2010	<350	<175
5/17/2010	11101 ± 324	10746 ± 308	5/17/2010	<350	<151
6/14/2010	10439 ± 314	10987 ± 323	6/14/2010	<350	<162

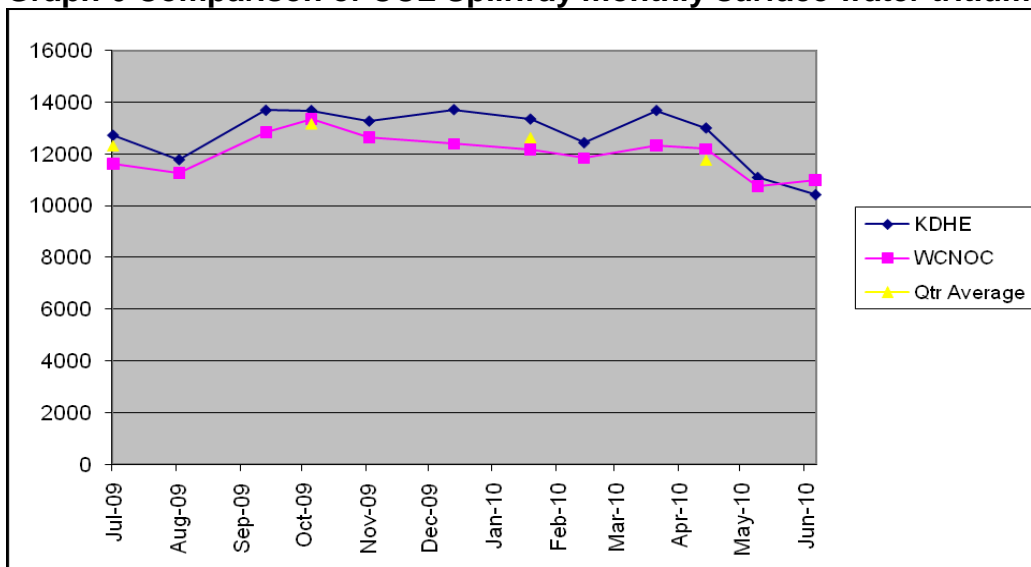
P-1 Muds		H-1 Neosho River	
Date	KDHE	Date	KDHE
7/14/2009	12270 ± 337		
8/24/2009	13596 ± 355		
9/8/2009	13541 ± 352	9/25/2009	<350
10/13/2009	13649 ± 354	10/27/2009	<350
11/12/2009	13016 ± 350	11/13/2009	<350
12/15/09	12872 ± 365	12/21/2009	<350
1/14/2010	12702 ± 365	1/27/2010	<350
2/18/2010	12722 ± 348	2/25/2010	<350
3/29/2010	13077 ± 353	3/28/2010	<350
4/29/2010	11498 ± 330	4/20/2010	<350
5/11/2010	11556 ± 328	5/11/2010	<350
6/9/2010	10635 ± 317	6/8/2010	<350

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Table 7 Annual samples for deposition of airborne radionuclides in surface water (pCi/L)

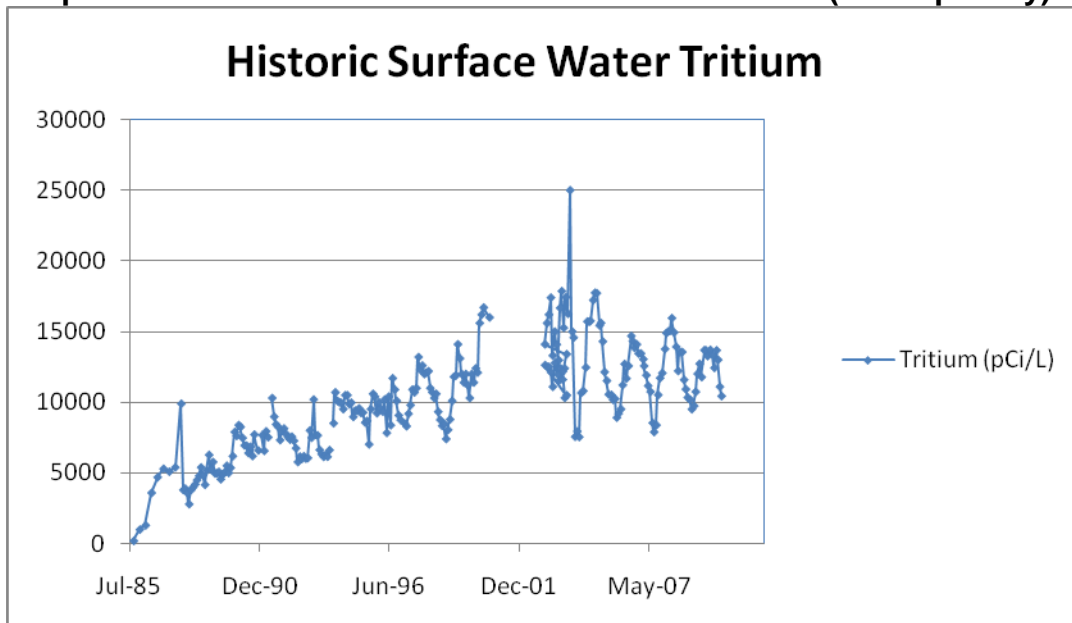
Location	Date	Tritium (^3H)
P-1, New Strawn City Lake	4/20/2010	<350

Graph 6 Comparison of CCL Spillway monthly surface water tritium results (pCi/L)



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Graph 7 Historical KDHE surface water tritium results (CCL Spillway)



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Ground Water

Ground water was collected quarterly offsite at wells in sectors B (control), C, F, G, and J. The control sample location was hydrologically up gradient from the facility and the other five are hydrologically down gradient. Samples were split with WCNOG. Samples were collected within the Wolf Creek owner controlled area along the Essential Service Water buried pipe (two locations) and in the Wolf Creek protected area near the Auxiliary Building.

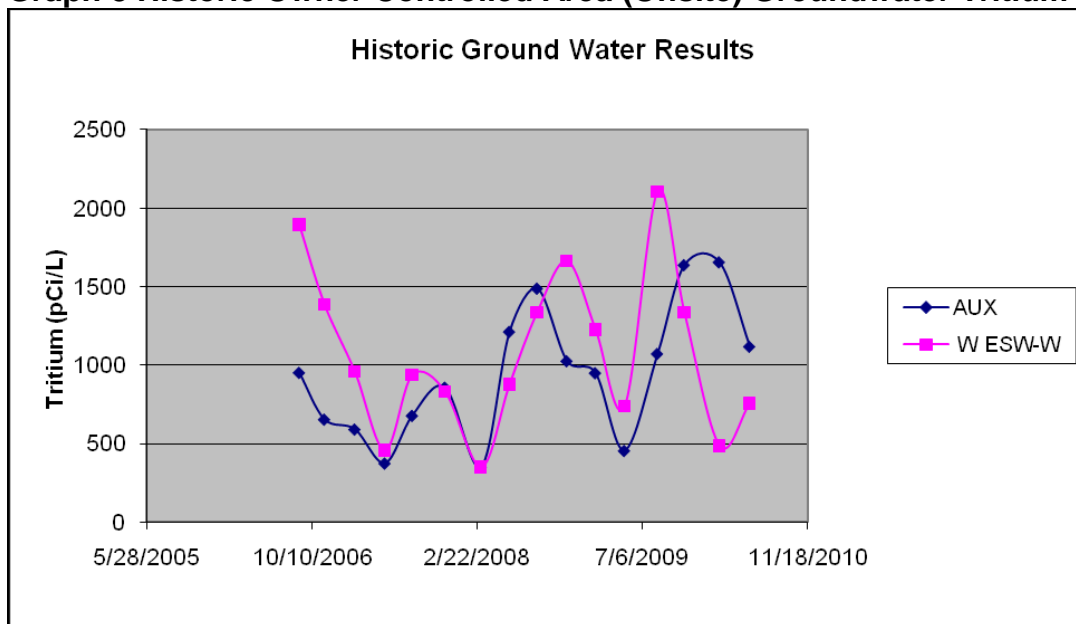
Gross alpha, beta, tritium and gamma isotopic analysis are done on each sample.

Table 8 Quarterly samples for waterborne radionuclides in ground water (pCi/L)

Offsite Ground Water					
B-1 (B-12)			G-1 (G-2)		
Date	H-3 KDHE	WCNOG	Date	H-3 KDHE	H-3 WCNOG
8/24/2009	<350	<146	8/24/2009	<350	<146
11/10/2009	<350	<150	11/10/2009	<350	<150
2/22/2010	<350	<152	2/22/2010	<350	<152
5/24/2010	<350	<146	5/24/2010	<350	<146
F-1 (F-1)			C-2 (C-49)		
Date	H-3 KDHE	WCNOG	Date	H-3 KDHE	H-3 WCNOG
8/24/2009	<350	<146	8/24/2009	<350	<146
11/10/2009	<350	<150	11/10/2009	<350	<150
2/22/2010	<350	<152	2/22/2010	<350	<152
5/24/2010	<350	<146	5/24/2010	<350	<146
J-1 (J-2)			C-1 (C-10)		
Date	H-3 KDHE	WCNOG	Date	H-3 KDHE	H-3 WCNOG
8/24/2009	<350	<146	8/24/2009	<350	<146
11/10/2009	<350	<150	11/10/2009	<350	<150
2/22/2010	<350	<152	2/22/2010	<350	<152
5/24/2010	<350	<146	5/24/2010	<350	<146
Onsite Ground Water					
Auxiliary Building			WEST ESW-W		
Date	H-3 KDHE	H-3 WCNOG	Date	H-3 KDHE	H-3 WCNOG
8/20/2009	1070 ± 183	1177 ± 125	8/20/2009	2106 ± 206	2060 ± 151
11/9/2009	1634 ± 194	1514 ± 137	11/9/2009	1335 ± 191	1120 ± 124
2/23/2010	1652 ± 199	1458 ± 131	2/23/2010	487 ± 179	445 ± 94
5/26/2010	1116 ± 182	1187 ± 134	5/6/2010	757 ± 176	681 ± 120
EAST ESW-W					
Date	H-3 KDHE	H-3 WCNOG			
8/25/2009	<350	<147			
11/9/2009	<350	<150			
2/23/2010	<350	<152			
5/26/2010	<350	274 ± 108			

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Graph 8 Historic Owner Controlled Area (Onsite) Groundwater Tritium



Shoreline and Bottom Sediments

Shoreline sediment and bottom sediment were collected in the environment surrounding WCGS. Indicator bottom sediment samples were collected in the Coffey County Lake discharge cove, public environmental education area, and the CCL MUDS public access fishing area. A control sample of bottom sediment was obtained from John Redmond Reservoir. Indicator shoreline sediment was collected at the CCL discharge cove, the CCL MUDS public access fishing area, Wolf Creek below the CCL dam, and Stringtown Cemetery. A control sample of shoreline sediment was collected at JRR. Eight random bottom sediments were collected on CCL. Eight random shoreline sediments were collected on CCL and the Neosho River. The CCL and JRR samples are split with WCNOG.

A gamma isotopic analysis is done on all sediment samples collected.

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Table 9 Annual samples for waterborne radionuclides in sediments (pCi/kg dry)

Location	Type	Date	¹³⁷ Cs KDHE (WCNOC)	⁶⁰ Co KDHE (WCNOC)	⁴⁰ K KDHE (WCNOC)
J-1 Wolf Creek	Shoreline	6/22/2010	29.7 ± 2.1	<11.0	11010.7 ± 146.7
Q-1 CCL Discharge Cove	Bottom	9/23/2009	106.7 ± 56.8 (125.5 ± 24.6)	<11.0 (57.9 ± 25.8)	14840 ± 1809 (13297.0 ± 805.9)
	Shoreline	9/23/2009	80.2 ± 6.2 (<85.8)	<11.0 (<46.9)	16481 ± 727.9 (12895 ± 1410)
N-1 John Redmond Reservoir (Control)	Bottom	9/23/2009	112.4 ± 10.7 (<53.0)	<11.0 (<28.6)	19681.6 ± 1197.5 (14224.0 ± 1250.0)
	Shoreline	9/23/2009		<11.0 (<19.5)	13459.2 ± 590.6 (10205.0 ± 652.1)
R-1 Wolf Creek Environmental Education Area	Shoreline	6/2/2010	136.8 ± 9.4 (101.9 ± 29.7)	<11.0 (<8.4)	12561.7 ± 604.9 (9892.2 ± 755.6)
	Shoreline	9/23/2009	149 ± 4.1	<11.0	11524.4 ± 138.2
P-1 CCL Public Access Fishing Area (MUDS)	Bottom	6/2/2010	27.9 ± 0.9 (<22.3)	<11.0 (<20.4)	10112.4 ± 119.9 (9695.8 ± 625.8)
R-2 Stringtown Cemetery	Shoreline	6/22/2010	106 ± 3.2	<11.0	12204.4 ± 143.1

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Table 10 Random samples for waterborne radionuclides in sediments (pCi/kg dry)

	Location	Date	Isotope	
			¹³⁷ Cs	⁶⁰ Co
Bottom Sediment	CCL North End	9/23/2009	13.5 ± 7.5	<11.0
	CCL North End	9/23/2009	28.7 ± 3.2	<11.0
	CCL North End	9/23/2009	35.9 ± 5.1	<11.0
	CCL	9/23/2009	23.9 ± 3.7	<11.0
	CCL	9/23/2009	48.7 ± 5.2	<11.0
	CCL North End	6/15/2010	20.5 ± 1.8	<11.0
	CCL North End	6/15/2010	29.6 ± 1.5	<11.0
	CCL North End	6/15/2010	82.0 ± 3.4	<11.0
	CCL	6/15/2010	36.2 ± 1.7	<11.0
Shoreline Sediment	Neosho River	9/25/2009	23.8 ± 5	<11.0
	Neosho River N of Burlington	4/7/2010	67.5 ± 3	<11.0
	Neosho River Burlington Fairgrounds	4/20/2010	10.7 ± 1.6	<11.0
	Neosho River Dam in Burlington	5/5/2010	<8.0	<11.0
	CCL Black Bear Bosin Recreation Area	5/5/2010	35.7 ± 3.2	<11.0
	CCL East of Dam	5/5/2010	203.5 ± 1.8	<11.0
	N End of CCL by 17th Rd. Bridge	5/26/2010	10.7 ± 1.6	<11.0

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Aquatic Vegetation and Algae

Annual aquatic vegetation (algae and/or rooted aquatics) indicator samples were collected from the Coffey County Lake and Wolf Creek below the Coffey County Lake dam. Control samples of aquatic vegetation were obtained at John Redmond Reservoir. The Coffey County Lake samples are split with WCNOG.

Gamma isotopic analysis is performed on all aquatic vegetation samples.

Table 11 Annual samples for waterborne radionuclides in aquatic vegetation KDHE (WCNOG)

Location	Sample type	Date	K-40 pCi/kg	Be-7 pCi/kg
Wolf Creek	Water Willow	6/22/2010	29437.9 ± 649.1	<360
JRR above dam	Duckweed	7/24/2009	17926 ± 1935	2435 ± 377
CCL MUDS	Pondweed	9/8/2009	10109 ± 714 (2501.5 ± 259.0)	3864 ± 266 (931.4 ± 183.0)
CCL DC	Cattails	6/22/2010	11383 ± 325.9	2727.4 ± 176.6
CCL EEA	Arrowhead Fern	8/14/2009	36784 ± 2647 (5171.0 ± 452.3))	1867 ± 326 (<200.5)

Table 12 Random samples for waterborne radionuclides in aquatic vegetation

Location	Sample Type	Date	K-40 pCi/kg	Be-7 pCi/kg
Near 15th and Shetland	Water Willow	7/7/2009	13097.0 ± 736.0	852.0 ± 93.0
16th and Verdure	Great Bullrush	7/14/2009	26681.0 ± 1485.0	<157
Between 15th and 16th on Underwood	Water Plantain	7/24/2009	17852.0 ± 1423.0	<157
City of Burlington	Horsetails	9/21/2009	19634.0 ± 543.0	<157
CCL	Naiad	9/23/2009	23308.0 ± 530.0	<157
West End CCL	Cattails	6/15/2010	13714.3 ± 385.4	2155.8 ± 156.4

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Attachment 5: Ingestion Pathway

Milk Samples

Milk samples were collected quarterly in Coffey County at two locations. Indicator samples were obtained from the Sunrise Dairy near Westphalia, KS. Control samples were obtained from Linsey Dairy near Lebo, KS. Each milk sample is analyzed for low levels of radioiodine and other gamma emitting nuclides.

Table 13 Quarterly samples for radionuclides in milk (pCi/L)

Linsey Dairy			Sunrise Dairy		
Date	I-131	K-40	Date	I-131	K-40
09/10/09	<1	1420 ± 85	9/24/2009	<1	1470 ± 86
12/17/2009	<1	1385 ± 82	11/25/2009	<1	1518 ± 80
2/4/2010	<1	1332 ± 35	3/29/2010	<1	1359 ± 55
05/17/10	<1	1458 ± 41	6/8/2010	<1	1602 ± 51

Fish/Game Animals/Domestic Meat Samples

Fish samples were collected from the Coffey County Lake and below John Redmond Reservoir on the Neosho River. Sample portions from fish collected in the Coffey County Lake and below John Redmond Reservoir on the Neosho River were split with WCNOG. Fish collected at John Redmond Reservoir on the Neosho River are used for control samples.

Game animal sampling is usually limited to the collection of edible meat portions from road-killed deer. Sample portions of road-killed deer are usually collected as available by WCNOG and split with KDHE for laboratory analysis. One deer sample was obtained during SFY 2010.

A gamma isotopic analysis is done on all samples collected. Sample portions were edible. Tritium in tissue analysis (fat and water) is done on at least one species of fish from each location sampled. Only results for KDHE tritium analysis are listed in table 14. No gamma emitting radionuclides were detected in any fish specimen collected over this period.

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Table 14 Annual samples for radionuclides in fish (pCi/kg, wet)

Location	Date	Description	³ H pCi/Kg KDHE (WCNOC)
Q-1 CCL	10/15/2009	Wiper Channel Catfish Walleye	6902 ± 356 (8,895 ± 250) 7241 ± 363 (9,550 ± 262) 7634 ± 363 (7,760 ± 236)
	5/25/2010	Smallmouth Buffalo	7662 ± 301 (6,096 ± 199)
N-1 (JRR) John Redmond Reservoir Below dam on Neosho River (Control)	9/23/2009	Common Carp Channel Catfish Smallmouth Buffalo	<1200 (<118) <1200 (<117) <1200 (<121)
	5/25/2010	White Crappie Smallmouth Buffalo Channel Catfish Largemouth Bass	<1200 (<123) <1200 (<116) <1200 (<119) <1200 (<132)

Table 15 Random samples for radionuclides in game (pCi/kg, wet)

Sample Location	Date	Sample Type	KDHE(WCNOC)	
			K-40	Be-7
1.0 Mile NNE of WCNOC	10/28/2009	Deer	2487 ± 316 (2,379.0 ± 364.7)	<78 (Not Reported)

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Terrestrial Vegetation/Human Food Products

Terrestrial vegetation samples were taken at various locations around WCGS. Samples collected on WCNOG property and samples of crops were split with WCNOG. A control sample was collected at Scott Valley Church approximately 6 miles from WCGS. Ten random samples were collected from locations around WCGS within the 50 mile zone.

A gamma isotopic analysis was done on each vegetation sample and edible portions of food products collected.

Table 16 Annual samples for radionuclides in terrestrial vegetation/human food products

Location	Sample type	Date	K-40 pCi/kg KDHE (WCNOG)	Be-7 pCi/kg KDHE (WCNOG)
Scott Valley Church (Control)	Red Milo	10/6/2009	14208 ± 242	2116 ± 44.0
Sharpe	Soybeans	11/19/2009	14783 ± 247	<360
NR-U1	Irrigated Soybeans	11/27/2009	13769 ± 165 (11,934.0 ± 390.8)	<360 (<70.0)
NR-U1	Irrigated Corn	11/27/2009	2531 ± 50 (2,597.0 ± 247.4)	<360 (<48.3)
NR-D1	Irrigated Soybeans	12/01/2009	13769 ± 165 (12,979.0 ± 431.7)	<360 (<73.5)
NR-D2	Irrigated Soybeans	11/05/2009	13745.3 ± 285.1 (13,457.0 ± 402.7)	<360 (<109.7)
NR-D2	Irrigated Corn	11/09/2009	2721 ± 54 (2,944.9 ± 240.4)	<360 (<81.1)
MUDS	Pasturage	09/08/2009	7783 ± 944 (4,505.5 ± 412.3)	8308± 560 (1,421.2 ± 186.3)
EEA	Pasturage	08/14/2009	19954 ± 1511 (10,264.0 ± 621.4)	5141± 427 (4,592.8 ± 313.2)

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Table 17 Random samples for radionuclides in terrestrial vegetation/human food products

Location	Sample type	Date	K-40 pCi/kg KDHE	Be-7 pCi/kg KDHE
Forward Staging Area	Chicory	8/10/2009	26395 ± 1599	1467 ± 195
Linsey Dairy	Tomatoes	9/8/2009	1729 ± 149	<360
1/4 Mi. W. of 8th and Shetland	Corn on Cob	9/25/2009	3598 ± 73	<360
21st and Native	Red Milo	9/29/2009	4093 ± 293	1313 ± 97
11th and Oxen Lane	Corn on Cob	10/1/2009	3773 ± 316	<360
Near 19th and Juneberry	Soybeans	10/6/2009	10800 ± 273	1255 ± 49
Near 12th and Underwood	Corn (Kernel)	10/6/2009	2900 ± 51	<360
Near 16th and Shetland	White Milo	10/13/2009	3839 ± 87	813 ± 19
Near 22nd and Blackbird	Sunflower	11/3/2009	15659 ± 261	363 ± 25
18 th and Yearling	Wheat	6/9/2010	4304 ± 133	1957 ± 66

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Attachment 6: KDHE Radiochemistry Laboratory

Quality Assurance

The KDHE Radiation Laboratory has an established internal Quality Assurance program. Quality Control elements include routine calibrations and performance checks on counting equipment and participation in an environmental radioactivity laboratory intercomparison studies program. This program is currently accomplished with blind samples purchased from Environmental Resource Associates. Results for SFY 2010 are presented in Table 18.

Equipment

The following is a description of the equipment used by the KHEL Radiochemistry laboratory.

Multichannel gamma-spectrometer

Gamma radiation is measured spectra determined with a Canberra Genie-2000 Multichannel Analyzer (MCA) system. Detectors available are three high purity germanium detectors (efficiencies – 20 % - 40%) and one germanium-lithium (GeLi) Detector (efficiency 20%).

Low background alpha/beta system

Low background alpha/beta gas-flow internal proportional counters – one Tennelec LB5100, one Oxford Series 5XLB, one Tennelec LB4000 multi-detector and one Canberra 2201.

Internal proportional counter (IPC)

Gross alpha and radium analyses are performed with windowless gas-flow internal proportional counters – four Protean MPC 2000 and two NMC PC5.

Liquid scintillation

Analysis for tritium in water is performed using a one Wallac 1409 and one PE Tri-Carb 3100 TR.

Miscellaneous equipment

The Radiochemistry Section has various devices used for special purposes. A Ludlum Model 2200 single channel analyzer is used with a radon flask scintillation counter for radon and radium analyses. Another Ludlum Model 2200 single channel analyzer is used with a halogen quenched GM pancake probe for routine monitoring of personnel and incoming samples.

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Table 18 KDHE Radiochemistry Laboratory ERA Intercomparison Studies

Analyte	Date	Average Reported Value (pCi/L)	Assigned Value (pCi/L)	Acceptance Limits (pCi/L)	Performance Evaluation
Sr-89	2/25/10	53.97	53.3	42.3-60.9	Acceptable
	5/20/10	59.3	60.4	48.6-68.2	Acceptable
	8/20/10	56.1	55.3	44.1-62.9	Acceptable
Sr-90	2/25/10	40.18	42.2	31.1-48.4	Acceptable
	5/20/10	40.2	41.3	30.4-47.4	Acceptable
	8/20/10	31.5	32.8	24.0-38.0	Acceptable
Ba-133	2/25/10	70.71	72.9	61.0-80.2	Acceptable
	8/20/10	84.0	89.1	75.0-98.0	Acceptable
Cs-134	2/25/10	60.72	63.4	51.5-69.7	Acceptable
	8/20/10	83.0	88.3	72.4-97.1	Acceptable
Cs-137	2/25/10	115.62	120	108-134	Acceptable
	8/20/10	207.3	210	189-232	Acceptable
Co-60	2/25/10	92.58	90.0	81.0-101	Acceptable
	8/20/10	76.4	72.8	65.5-82.5	Acceptable
Zn-65	2/25/10	221.42	210	189-246	Acceptable
	8/20/10	115.7	110	99.0-131	Acceptable
Gross Alpha	2/25/10	44.78	42.5	22.0-53.9	Acceptable
	5/20/10	34.0	32.9	16.9-42.6	Acceptable
	8/20/10	55.1	61.1	32.0-75.9	Acceptable
Gross Beta	2/25/10	56.87	54.2	37.0-61.1	Acceptable
	5/20/10	32.2	37.5	24.7-45.0	Acceptable
	8/20/10	46.5	56.4	38.6-63.3	Acceptable
I-131	2/25/10	29.61	28.2	23.5-33.1	Acceptable
	5/20/10	29.1	26.4	21.9-31.1	Acceptable
	8/20/10	28.9	28.4	23.6-33.3	Acceptable
H-3	2/25/10	21423	18700	16400-20600	Not Acceptable*
	5/20/10	20102	19800	17300-21700	Acceptable

**Lab results considered valid as long as no two consecutive PE samples are adjudged as "Not Acceptable". Retest on May 20 was "Acceptable".*

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Table 19 Method Detection Limits

GeLi [HPGe] detection system^a						
Environmental Sampling						
	Water and Milk	Filter	Wipe	Soil and Sediment	Biota	Vegetation and Food Products
Minimum sample size	2000 ml	1500 m ³	Total	0.45 kg	0.3 kg	1 kg
Minimum Counting Time	8 hr.	3 hr	3 hr.	15 hr.	15 hr.	15 hr.
Method Detection Limit	pCi/L	pCi/m ³	pCi/wipe	pCi/kg-dry	pCi/kg-wet	pCi/kg-dry
⁷ Be	64 [22]	0.03 [0.02]	N/A	346 [186]	231 [144]	35 [19]
⁴⁰ K	88 [39]	0.03 [0.02]	N/A	828 [654]	459 [262]	152 [72]
⁵¹ Cr	52 [32]	0.01 [0.009]	5 [3]	35 [22]	41 [32]	55 [46]
⁵⁴ Mn	4 [2]	0.004 [0.003]	1 [0.7]	44 [11]	30 [15]	72 [24]
⁵⁸ Co	4 [2]	0.008 [0.002]	2 [1]	45 [23]	37 [20]	92 [36]
⁵⁹ Fe	8 [3]	0.01 [0.01]	3 [2]	51 [16]	41 [15]	97 [52]
⁶⁰ Co	11 [7]	0.01 [0.0053]	2.5 [1.7]	56 [35]	43 [26]	79 [50]
⁶⁵ Zn	8 [4]	0.01 [0.007]	N/A	48 [30]	38 [22]	93 [63]
⁹⁵ Nb	7 [3]	0.009 [0.007]	2.5 [1.4]	68 [30]	44 [26]	9 [4]
⁹⁵ Zr	6 [3]	0.01 [0.002]	0.5 [0.3]	35 [27]	27 [19]	84 [54]
⁹⁹ Mo	5 [3]	0.002 [0.0014]	1 [0.6]	73 [43]	33 [21]	****
¹⁰³ Ru	10 [7]	0.004 [0.003]	N/A	29 [20]	29 [21]	69 [47]
¹⁰⁶ Ru	55 [43]	0.07 [0.05]	1.5 [1]	269 [192]	43 [29]	96 [65]
^{110m} Ag	4 [3]	0.006 [0.0002]	N/A	47 [33]	47 [34]	86 [55]
¹²⁵ Sb	35 [12]	0.02 [0.01]	N/A	97 [44]	96 [51]	15 [6]
¹³¹ I	5 [3] (1) ^b	0.00027 [0.00027] ^c	1.5 [1]	33 [20]	37 [23]	45 [13]
¹³⁴ Cs	5 [3]	0.007 [0.004]	1.4 [1]	44 [29]	37 [24]	57 [39]
¹³⁷ Cs	7 [4]	0.006 [0.004]	1 [0.3]	49 [29]	32 [21]	80 [56]
¹⁴⁰ Ba	10 [6]	0.004 [0.003]	N/A	26 [17]	24 [15]	60 [39]
¹⁴⁰ La	9 [5]	0.01 [0.02]	N/A	28 [9]	34 [21]	13 [6]
¹⁴¹ Ce	8 [3]	0.002 [0.001]	N/A	46 [23]	22 [13]	6 [3]
¹⁴⁴ Ce	35 [14]	0.013 [0.0096]	N/A	216 [103]	110 [70]	28 [14]
²²⁶ Ra	116 [69]	0.05 [0.03]	N/A	828 [654]	323 [195]	90 [51]
²²⁸ Ac	30 [18] 15 h	0.0127 [0.0099]	N/A	68 [33]	146 [87]	27 [12]
²²⁸ Th	387 [142]	0.09 [0.06]	N/A	859 [317]	944 [356]	454 [167]
²³⁴ Th	618 [87] 15 h	0.159 [0.0423]	N/A	1009 [378]	1300 [556]	570 [94]
²³⁵ U	N/A	N/A	45 [30] 15 h	N/A	N/A	N/A
²³⁹ Np	41 [33]	0.01 [0.009]	5 [3]	64 [44]	40 [30]	97 [71]

^a GeLi = Germanium lithium; HPGe = High purity germanium.

^b Two methods of analysis are done: **1)** 8 hour direct gamma isotopic analysis of a 2000 mP milk or water sample that has a method detection limit (MDL) of 3 pCi/P, and **2)** 3 hour gamma isotopic analysis of ion exchange resin after a 1500 mP milk sample is filtered through an ion exchange column that has an MDL of 1 pCi/P.

^c The MDL for ¹³¹I when analyzing a charcoal cartridge is 0.03 [0.02] pCi/m³ based upon a 250 m³ sample volume. If the sample volume is increased to 1500 m³, the MDL is 0.002 [0.001] pCi/m³.

Method detection limits of present analytical methods for selected radionuclides monitored by the KHEL Radiochemistry Laboratory. These limits are intended as guides to order of magnitude sensitivities and are calculated with a 95% level of confidence (activity will be detected 95% of the time if it is present).

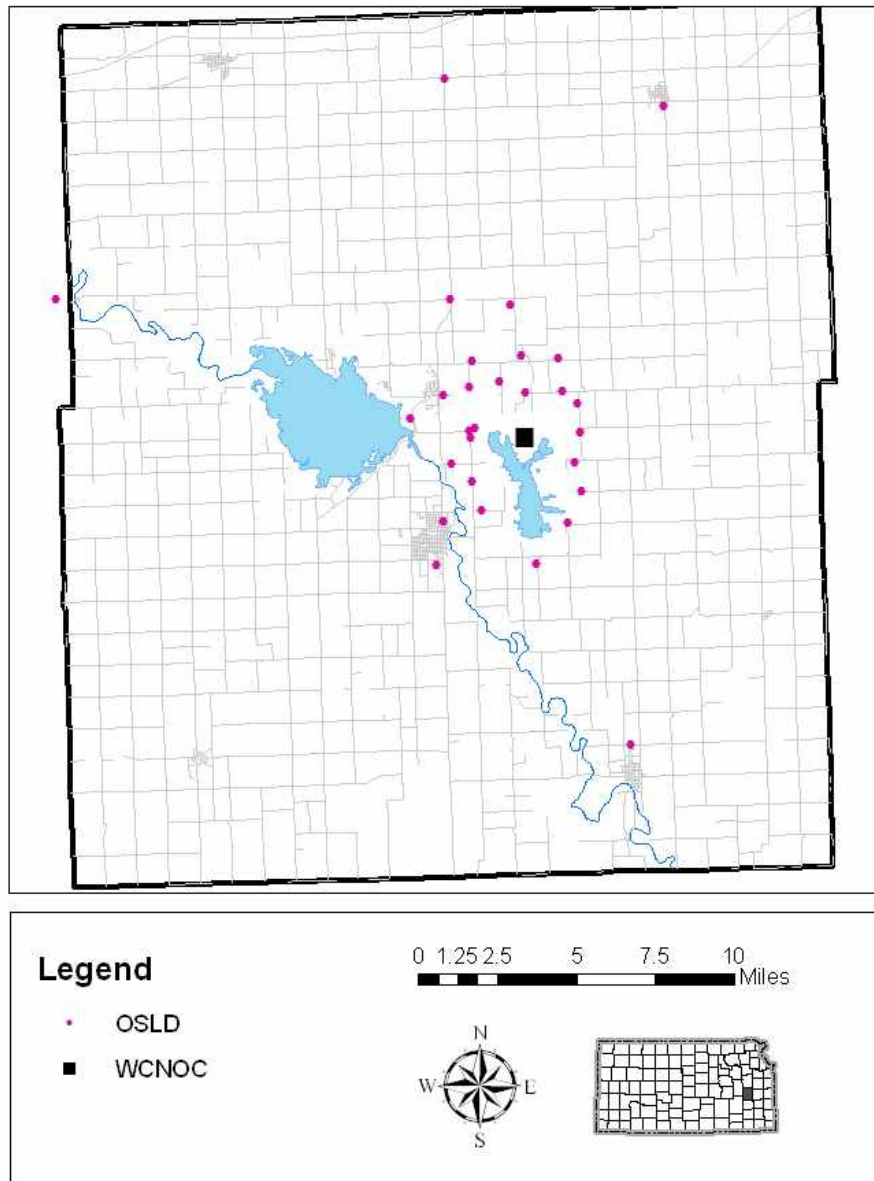
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Low Background Alpha and Beta Counting System					
	Water	Milk	Wipe	Soil & Sediment	Vegetation & Food products
Minimum Sample Size	1000 ml	1000 ml	Total	0.01 kg	0.1 kg
Minimum Counting Time	200 min.	200 min.	200 min.	200 min.	200 min.
Method Detection Limit	pCi/L	pCi/L	pCi/wipe	pCi/kg-dry	pCi/kg-dry
⁸⁹ Sr	1	2	3	200	500
⁹⁰ Sr	1	2	4	200	500
¹³¹ I	1	N/A	N/A	N/A	N/A
²²⁸ Ra	1.2	N/A	0.3	60	N/A
Gross Beta					
	Water	Filter	Wipe	Soil and Sediment	
Minimum Sample Size	200 ml	250 m ³	Total	0.001 kg	
Minimum Counting Time	200 min.	100 min.	100 min.	100 min.	
Method Detection Limit	4 pCi/l	0.004 pCi/m ³	2 pCi/Wipe	160 pCi/kg-dry	
Gross Alpha					
	Water	Filter	Wipe		
Minimum Sample Size	200 ml	250 m ³	Total		
Minimum Counting Time	200 min.	100 min.	100 min.		
Method Detection Limit	1 pCi/l	0.0006 pCi/ m ³	0.5 pCi/Wipe		
Random Scintillation Counting System					
²²⁶ Ra (radium) in water					
Minimum Sample Size		1000 ml			
Minimum Counting Time		200 min.			
Method Detection Limit		0.04 pCi/l			
Liquid Scintillation Counting System					
	³ H (Tritium)		²²² Rn (Radon)		
	In water	In Tissue	In Water		
Minimum Sample Size	10 ml	3 g	10 ml		
Minimum Counting Time	100 min.	120 min.	60 min.		
Method Detection Limit	350 pCi/l	1200 pCi/kg-wet	25 pCi/l		

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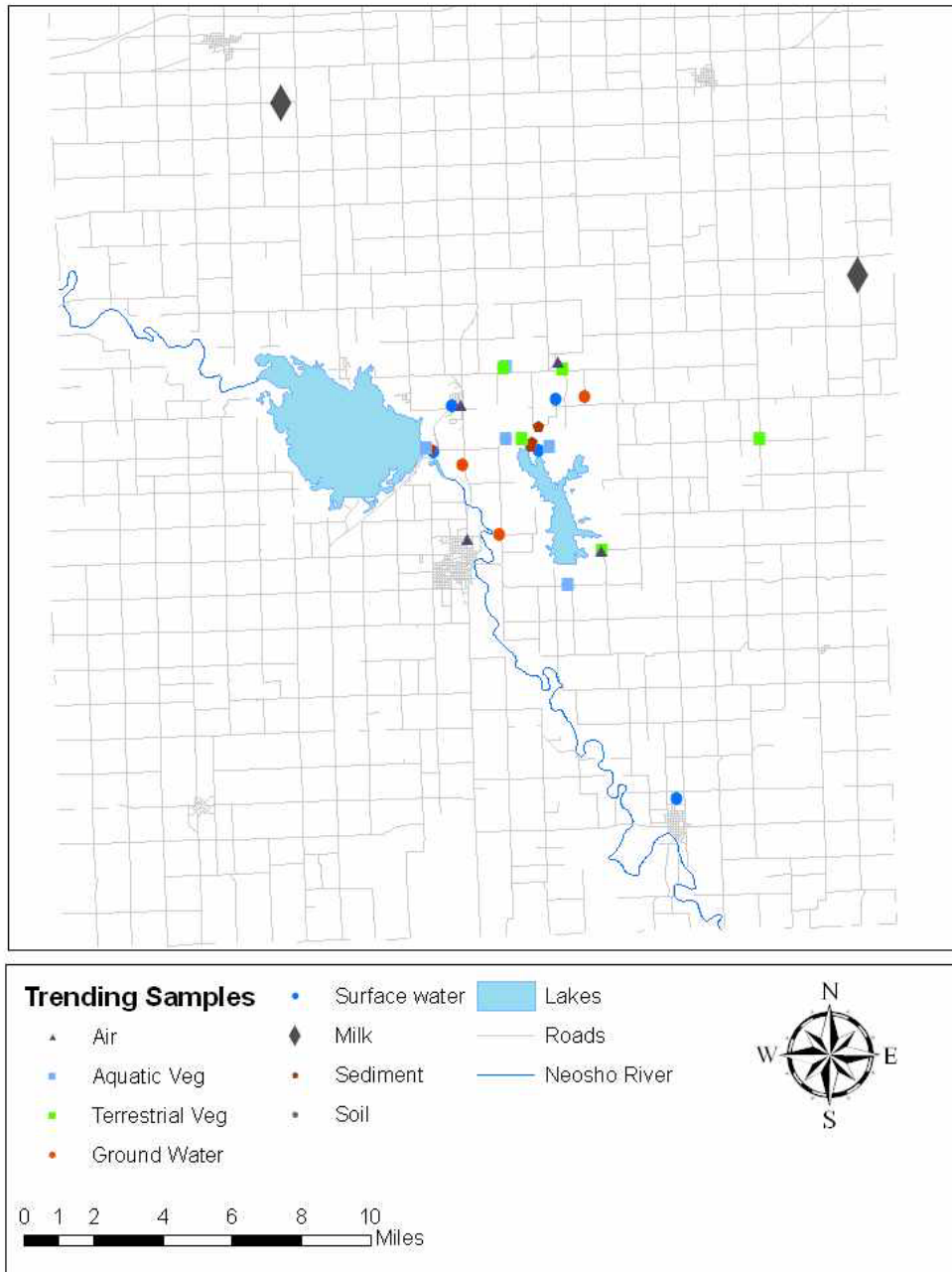
Attachment 7: Maps

Map 1 OSLD Locations



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Map 2 Routine Sample Locations



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Map 3 Random Sample Locations

